Physics-based Conceptual Design Tools for Weight Prediction (PBWeight)

OpenVSP Workshop 2016
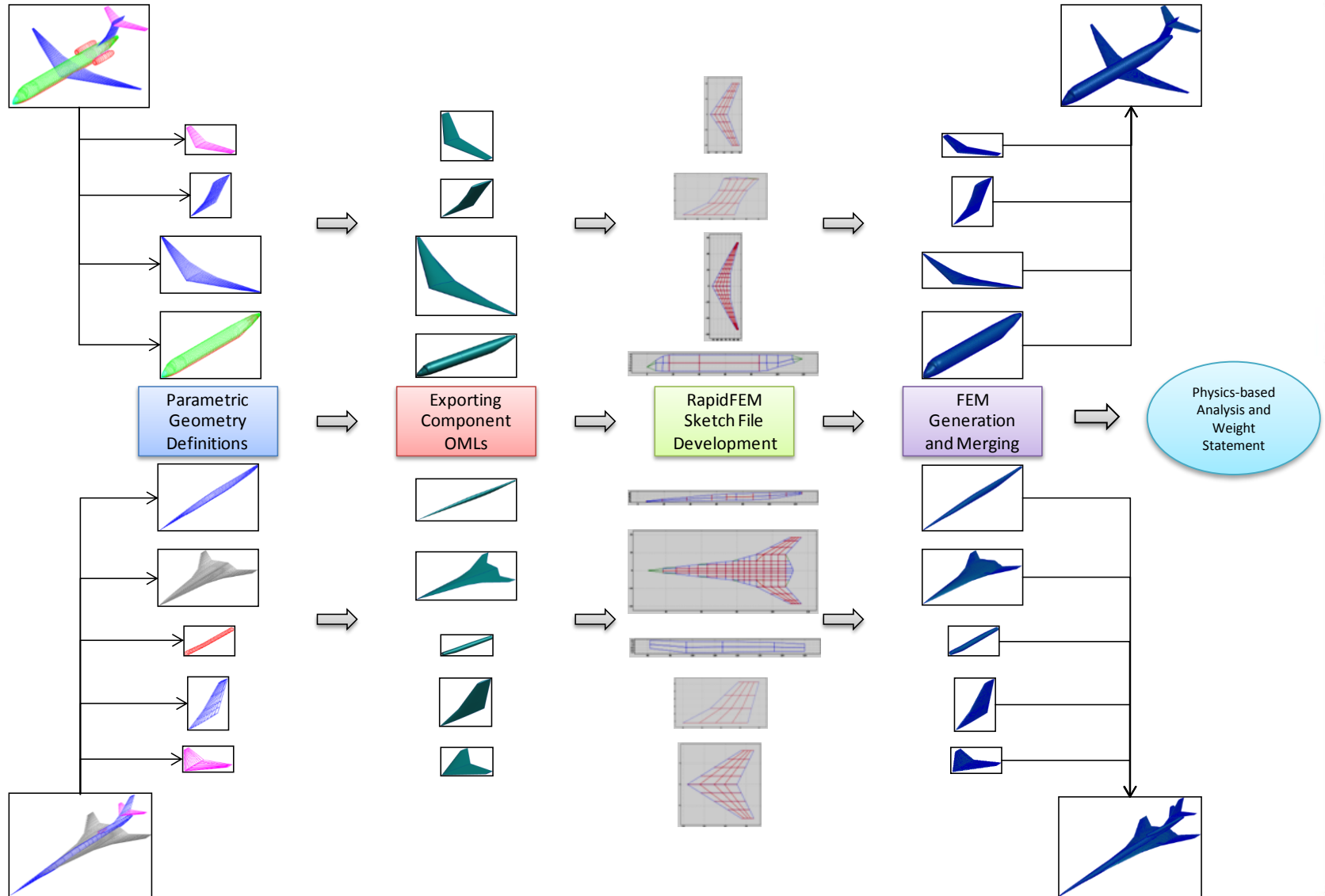
8/24/2016

NASA Ames

- Team Introduction
- PBWeight and RapidFEM Overview
- PBWeight Build 1.1 BETA Software
  - Package Overview
  - PBWeight Process Summary
  - Simple Wing Example Problem
    - (DEMO) Walkthrough
- Future Work

- # M4 Engineering, Inc.
  - CEO, Dr. Myles Baker
  - PI, Tyler Winter
- # PBWeight Team
  - Brent Scheneman
 - Donovan Fung
 - Phillip Chung
  - Matt Connolly

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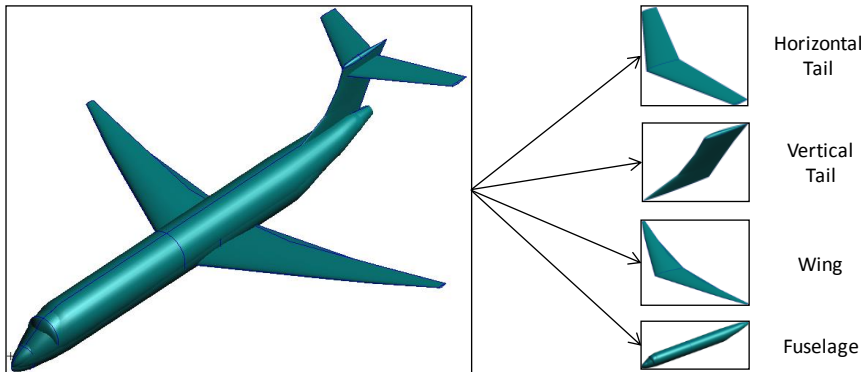   - (DEMO) Walkthrough
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M4 Engineering Proprietary

Parametric Geometry Definitions → Exporting Component OMLs → RapidFEM Sketch File Development → FEM Generation and Merging → Physics-based Analysis and Weight Statement

- Utilized OpenVSP software package to develop parametric geometry representations of the MD-87 and Low Boom configurations

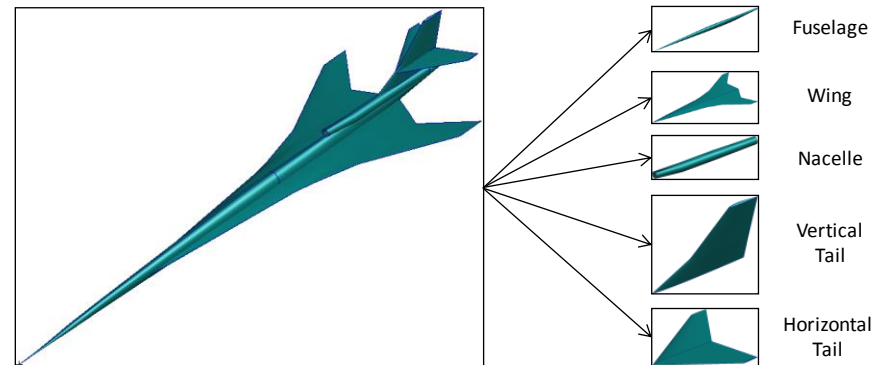- Were able to rapidly build models by placing schematics in the background and matching via overlays
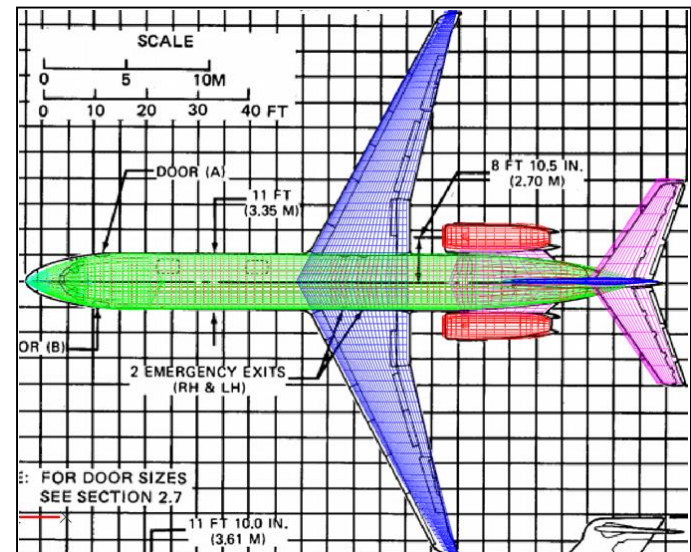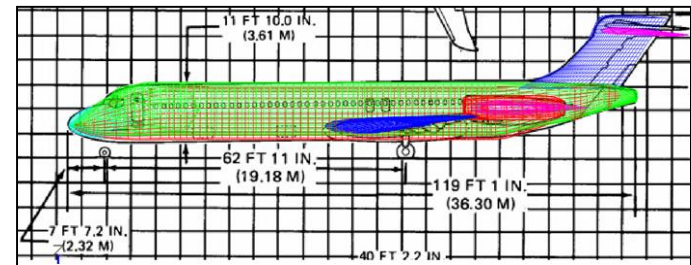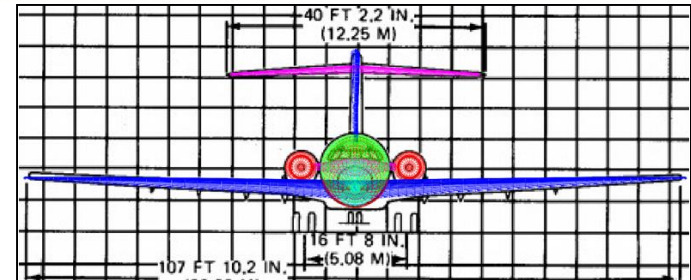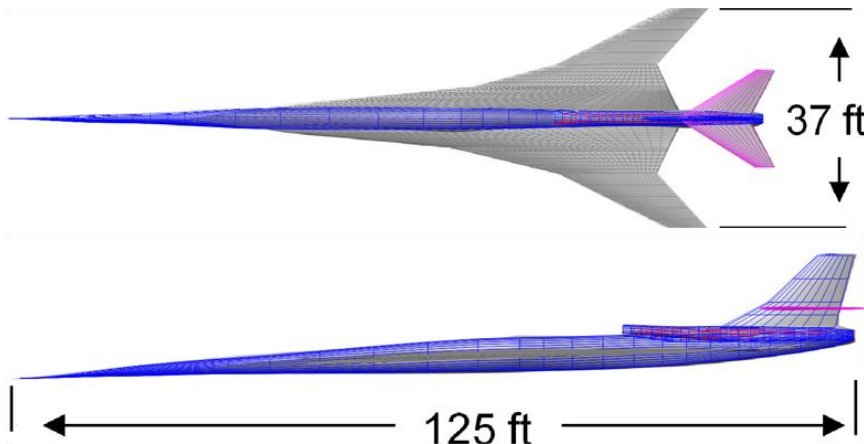
- RapidFEM requires OML representations for generating a bounding mesh for the internal structure of each component
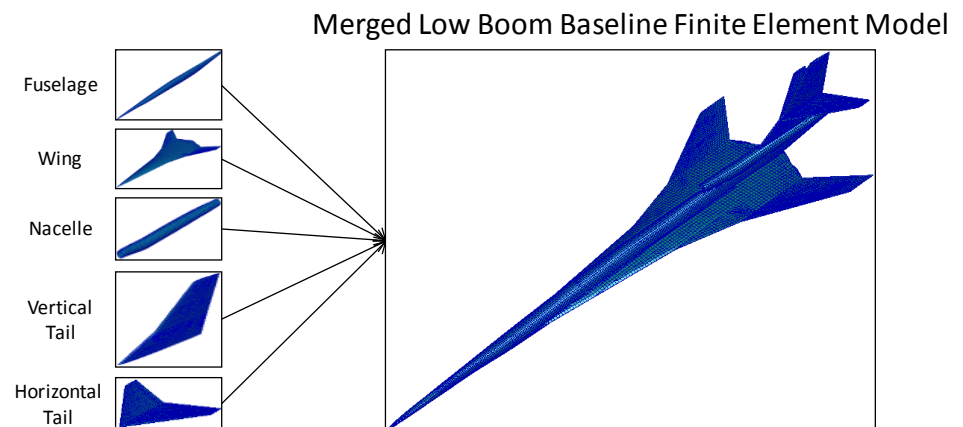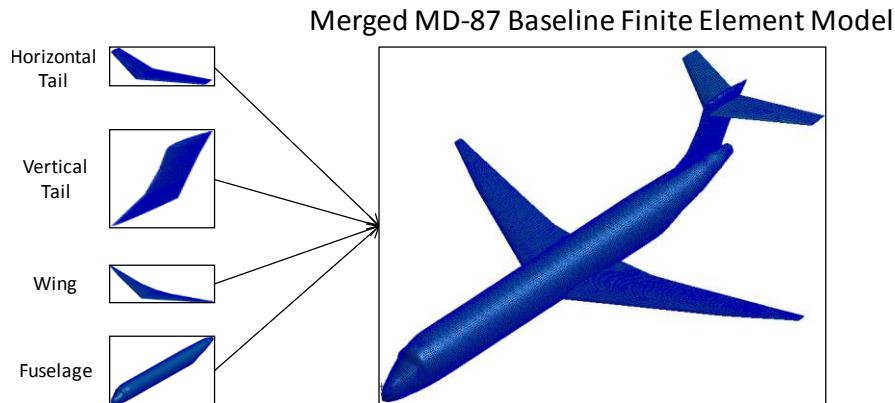

MD-87 Geometry

Horizontal Tail

Vertical Tail

Wing

Fuselage

Low Boom Geometry

Fuselage

Wing

Nacelle

Vertical Tail

Horizontal Tail

- Sketch file contains information defining 2-d "sketch" which is projected onto the OML to define the curves and surfaces needed for structural modeling and analysis

- Required for each component

- Involves defining internal structural layout, material property specifications, non-structural mass locations, control surfaces, load cases, and trimming/merging details

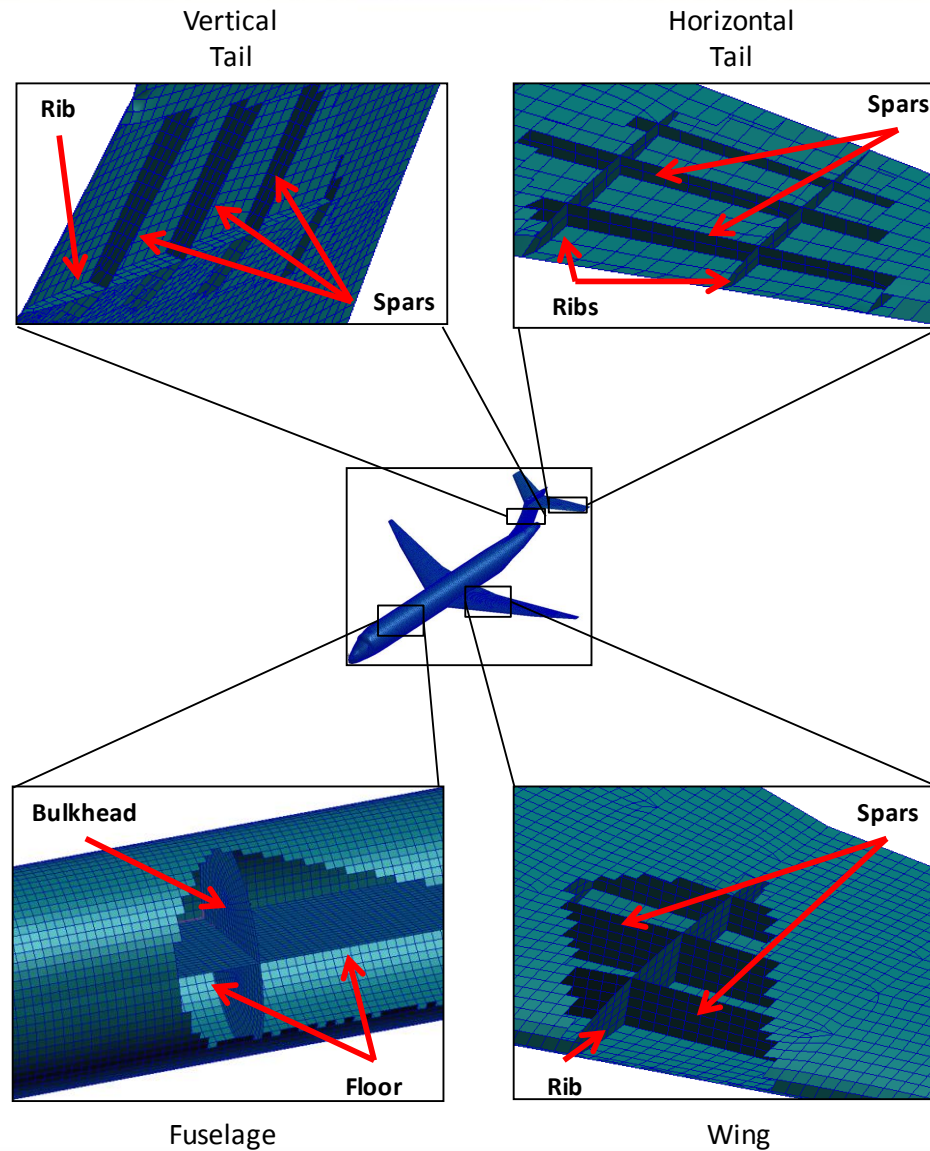- Have developed a sketch file visualization capability
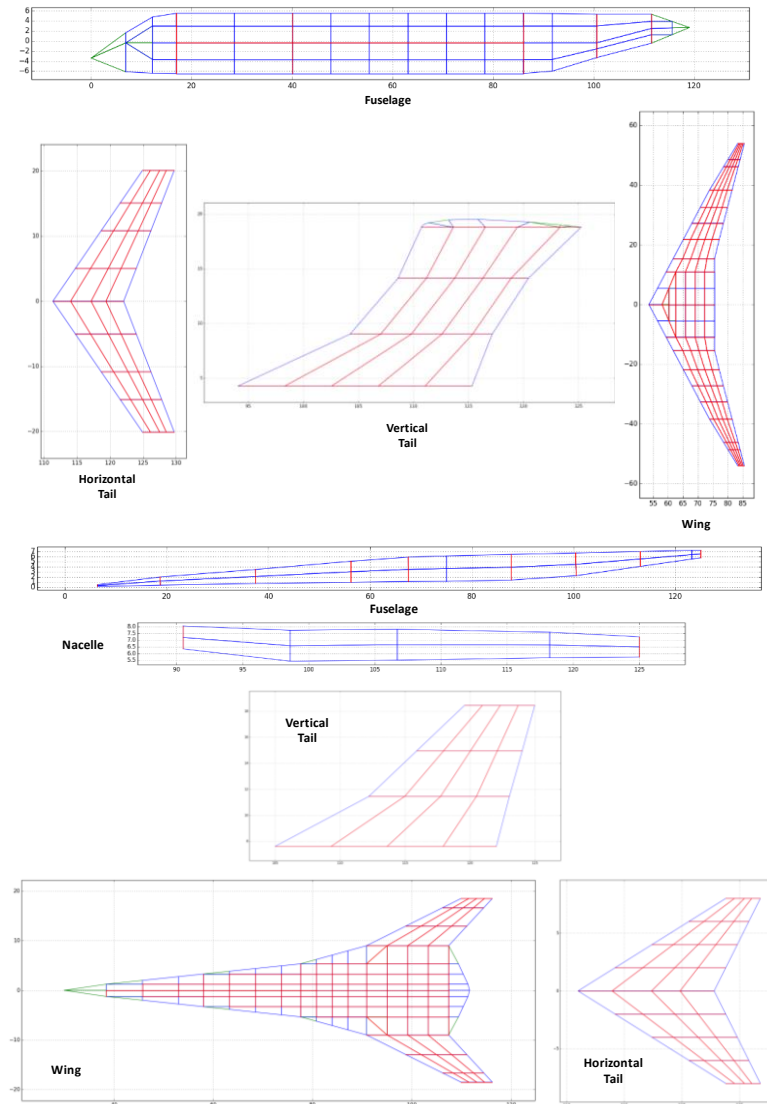
- The final step before analysis requires each component FEM to be generated and then merged/trimmed into a complete FEM
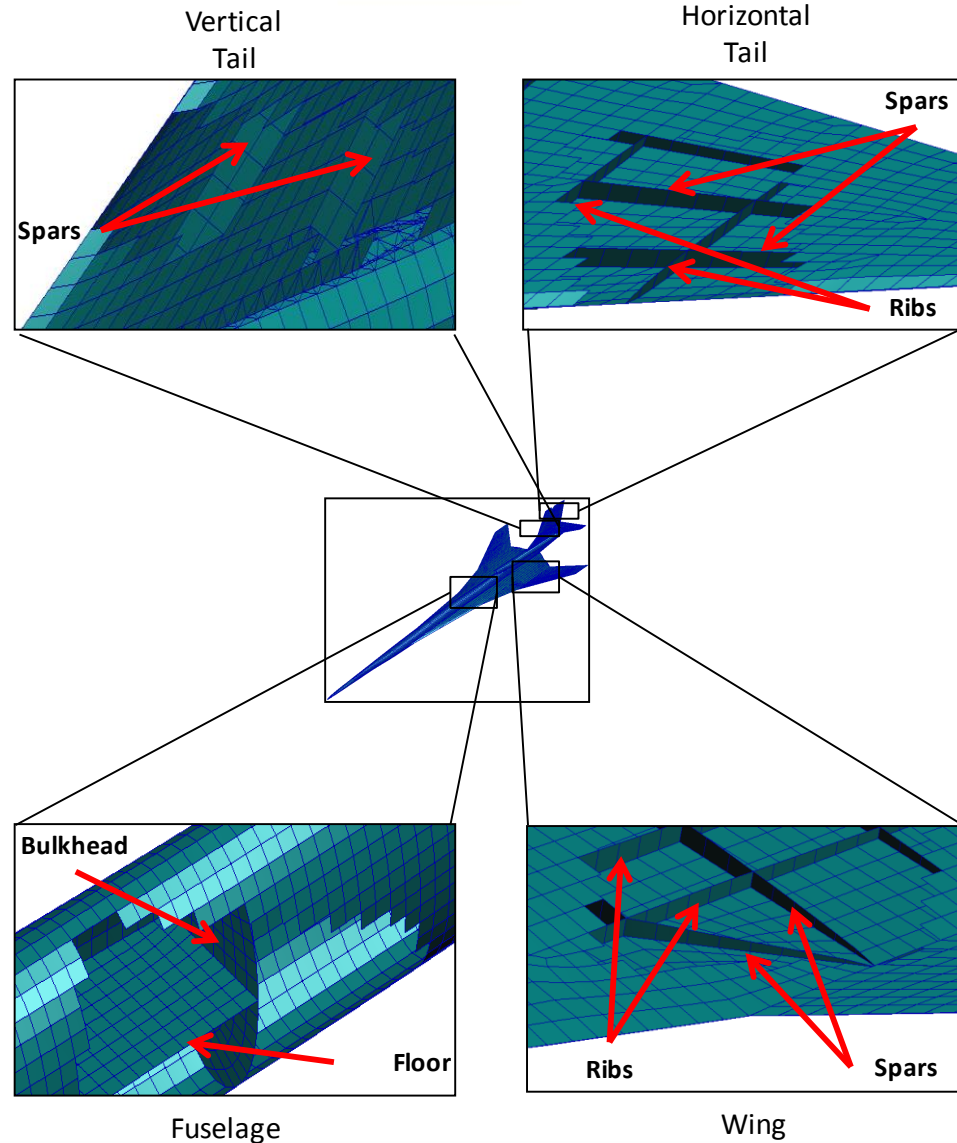

Merged MD-87 Baseline Finite Element Model

Horizontal Tail
Vertical Tail
Wing
Fuselage

Merged Low Boom Baseline Finite Element Model

Fuselage
Wing
Nacelle
Vertical Tail
Horizontal Tail

Baseline FEM and Internal Structural Layouts

- ## MD-87

Vertical Tail

Rib

Spars

Horizontal Tail

Spars

Ribs

Bulkhead

Floor

Spars

Rib

Fuselage

Wing

Baseline FEM and Internal Structural Layouts

- Low Boom
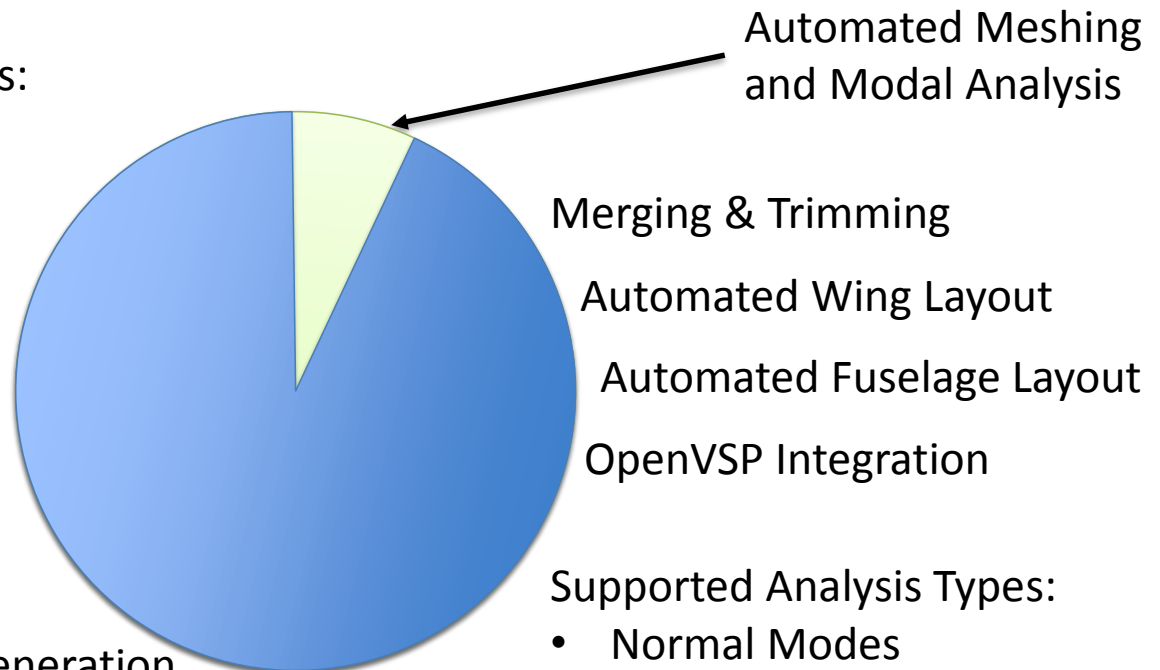

Vertical Tail

Horizontal Tail

Fuselage

Wing

- ## Overall goal is to streamline the internal structural layout process

Automated Capabilities:

- Fuel Tanks
- Bays
- Landing Gear
- Aero Panels
- Control Surfaces
- Splines

Support for:

- Parametric Trades
- Surrogate Model Generation
- Complete Weight Statement
- Comprehensive Load Case Library
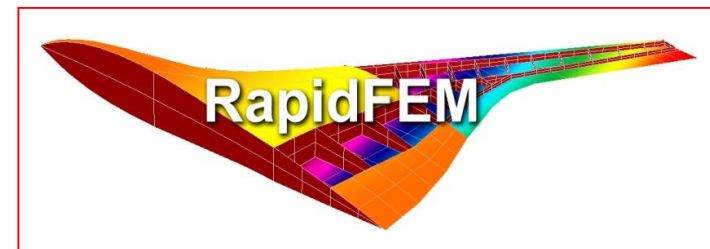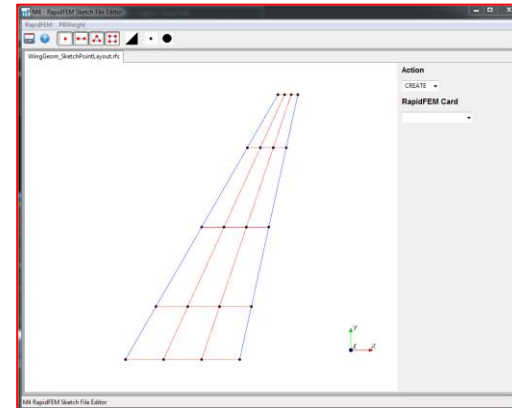- Composite Material Property Specification and Layup

Automated Meshing and Modal Analysis

Merging & Trimming

Automated Wing Layout

Automated Fuselage Layout

OpenVSP Integration

Supported Analysis Types:

- Normal Modes
- Linear Statics
- Static Aeroelastic
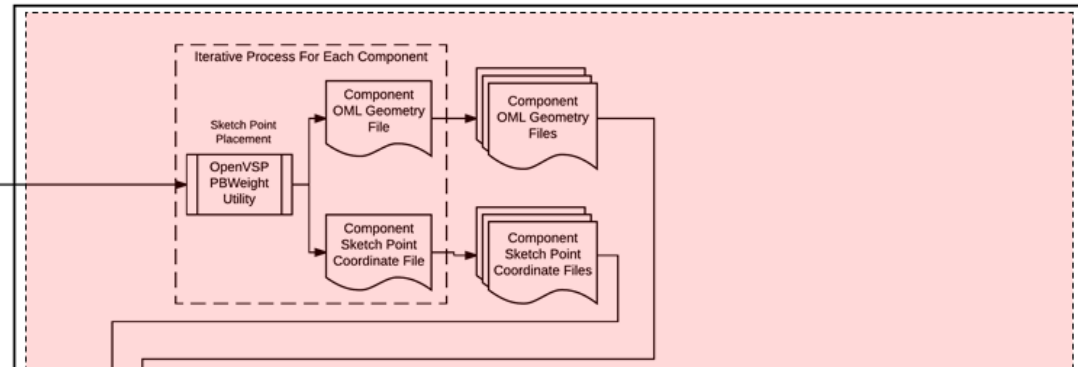- Flutter
- Optimization

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- ## PBWeight Build 1.1 BETA Software Package
  - Built and tested on Windows 7
  - OpenVSP 3.5.0 (M4 Distribution)
  - RapidFEM
    - RapidFEM_Batch_Run.exe
  - RapidFEM_SketchFileEditor.exe
  - Software User Manuals
    - PBWeight User Manual
    - RapidFEM User Manual
  - Examples
    - Example 0 (Simple Wing Example Problem)
   - Input Files
      - Results

- Team Introduction

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  – PBWeight Process Summary

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1. **Sketch Point Layout and OML Creation**

2. **Meta-Geometry Definition Creation**
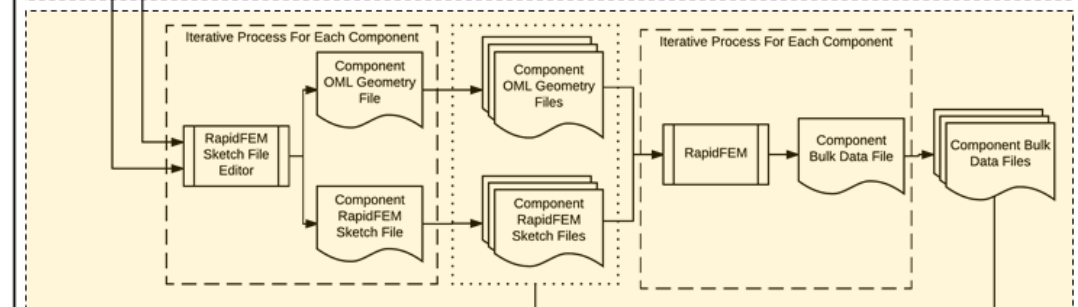
3. **FEM Creation**
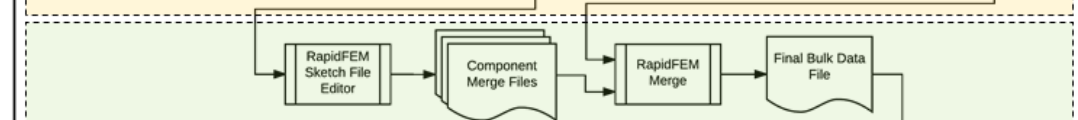
4. **Analysis and Weight Prediction**
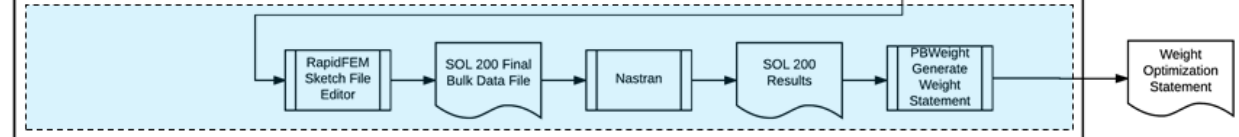
- Team Introduction

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   - (DEMO) Follow-Along Walkthrough

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- Example Objectives
  - Demonstrate how to create a sketch point layout in OpenVSP
  - Demonstrate how to configure a sketch file using the RapidFEM Sketch File Editor

- Problem Statement
  - Create a RapidFEM sketch file for a wing geometry with 14 elements given by the following design parameters: wing span (b), planform area (S), aspect ratio (AR), root/tip chords (c_R/c_T), and leading edge sweep angle (Λ)
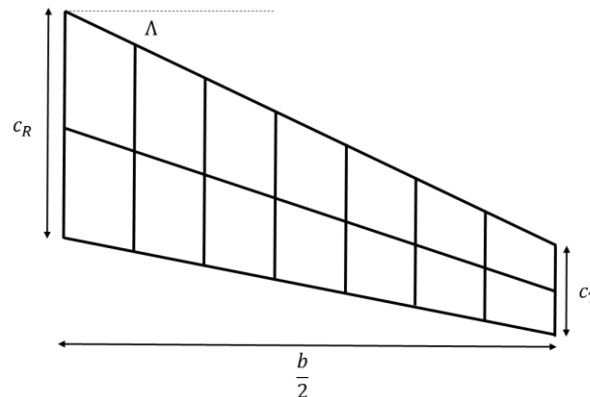
- ## Component Type: Wing
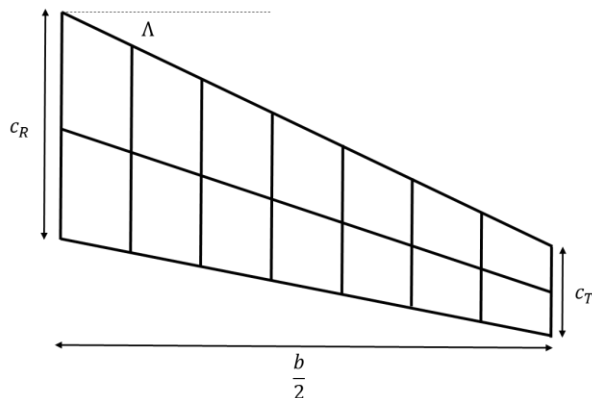
$b/2$	S	AR	c_R	c_T	Λ
647.00	106431	3.93	280	49.00	30°
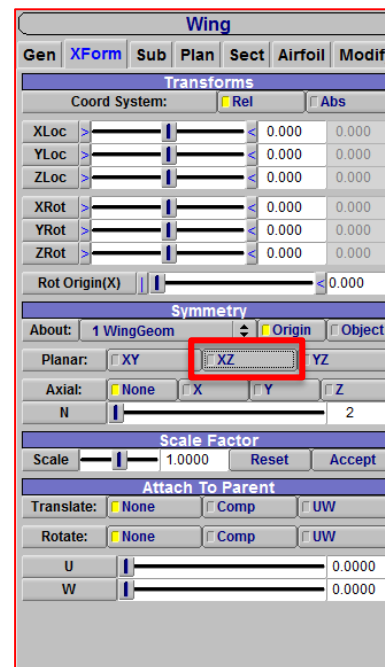
Deselect XZ Plane
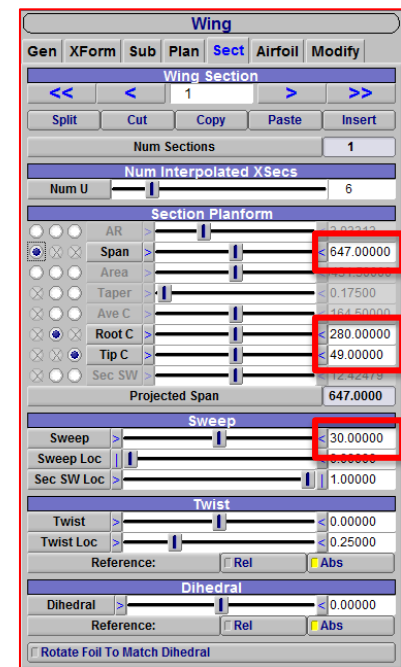
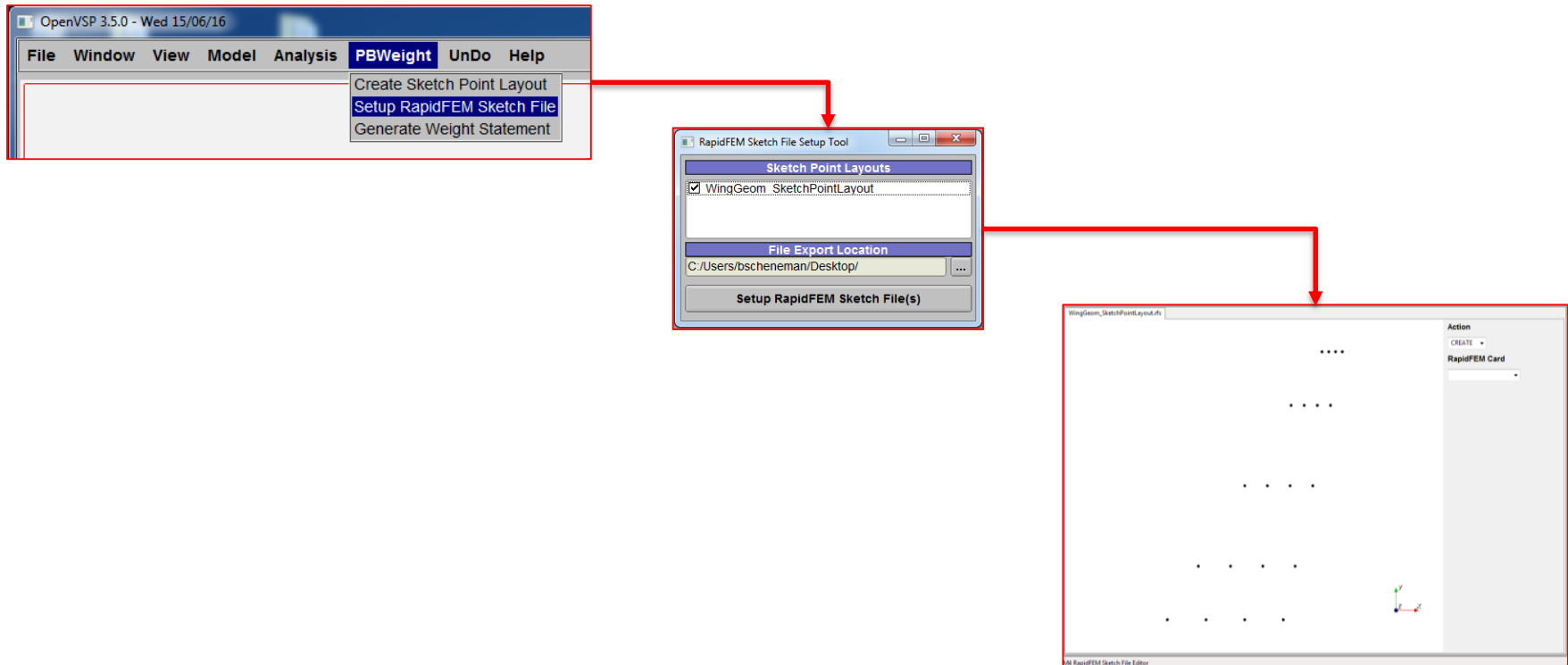Set Span, Root Chord, Tip Chord, and Sweep
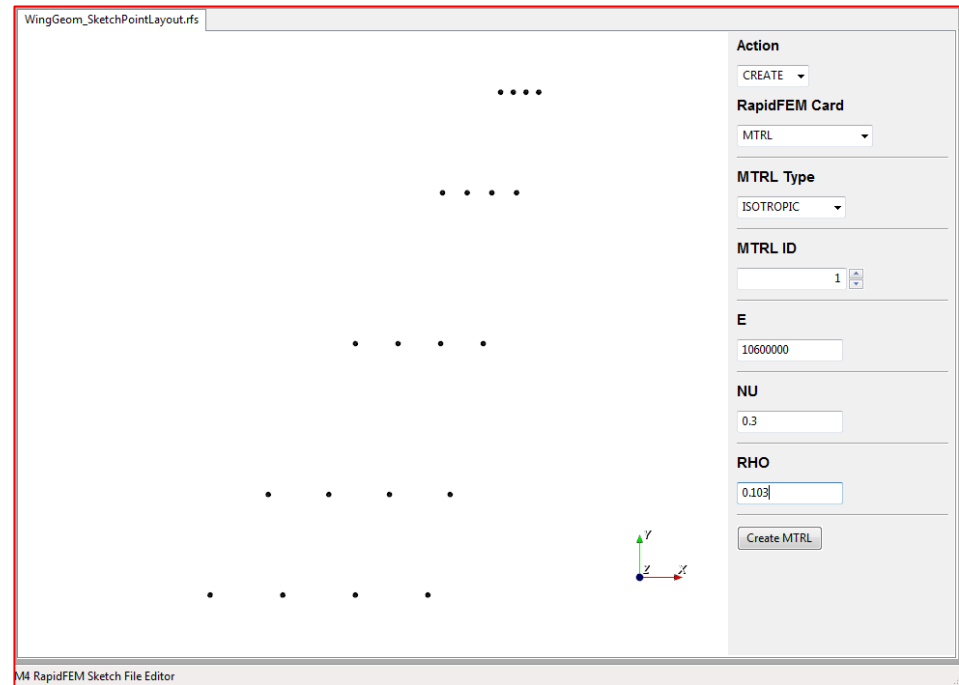
- ## Create Sketch Point Layout
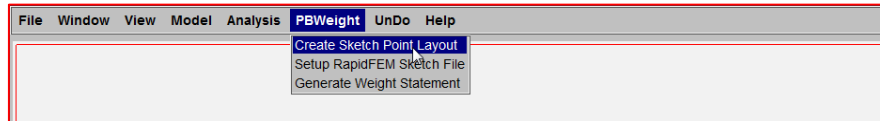
- ## Place Points
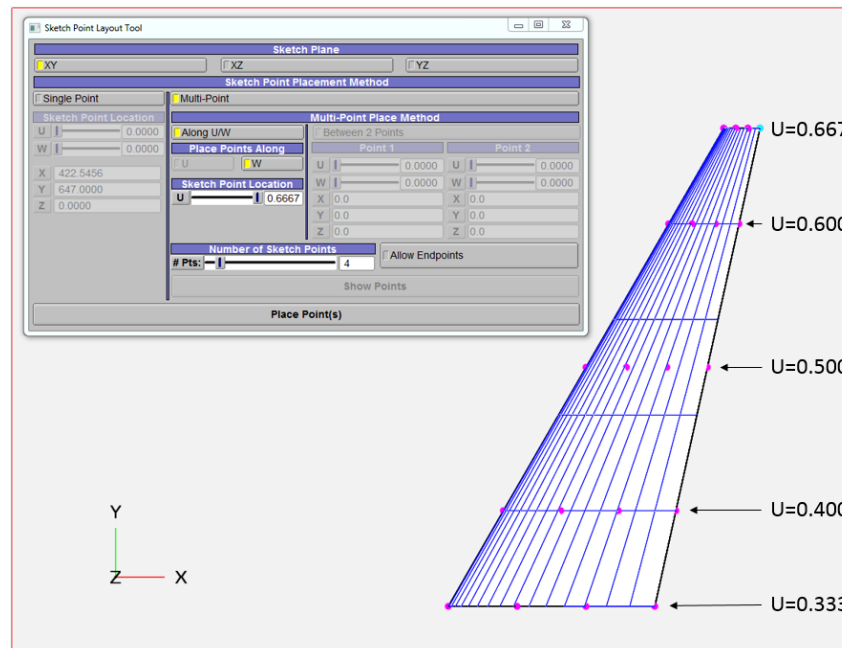
- Specify Sketch Point Layout to be exported
- Specify Export Location
- Multiple layouts can be exported at once
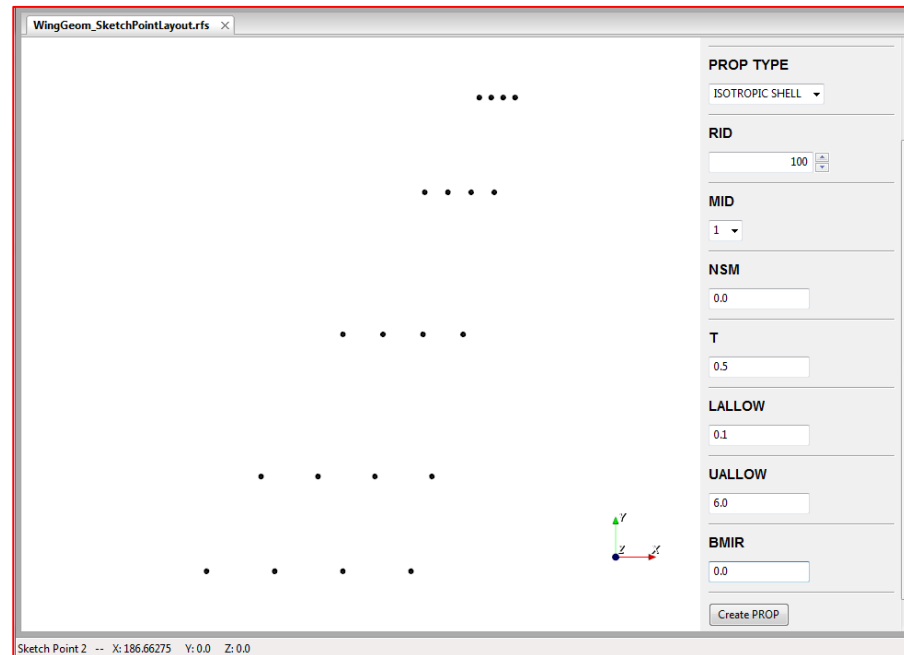- M4 RapidFEM Sketch File Editor will Automatically open with the Sketch Point Layout

- Action: Create
- RapidFEM Card: MTRL
- MTRL Type: ISOTROPIC

Card	MID	E	NU	RHO
mtrl	1	10600000	0.3	0.1030

- ## Action: Create

- ## RapidFEM Card: PROP
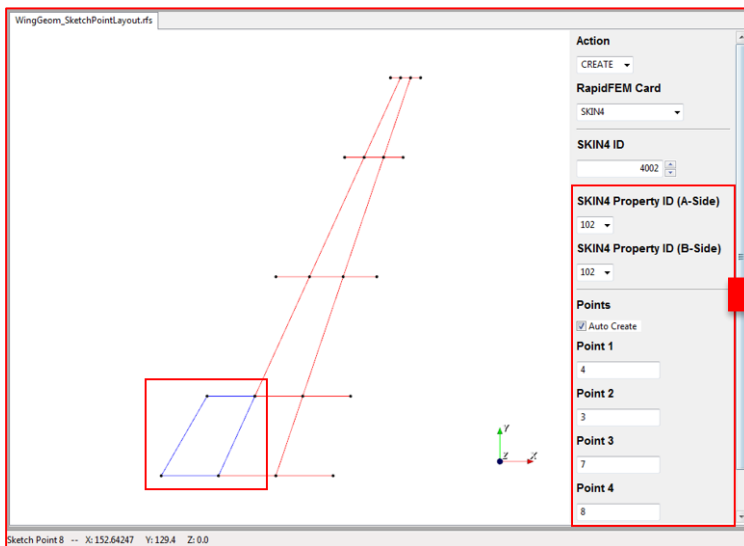
- ## Prop Type: ISOTROPIC SHELL

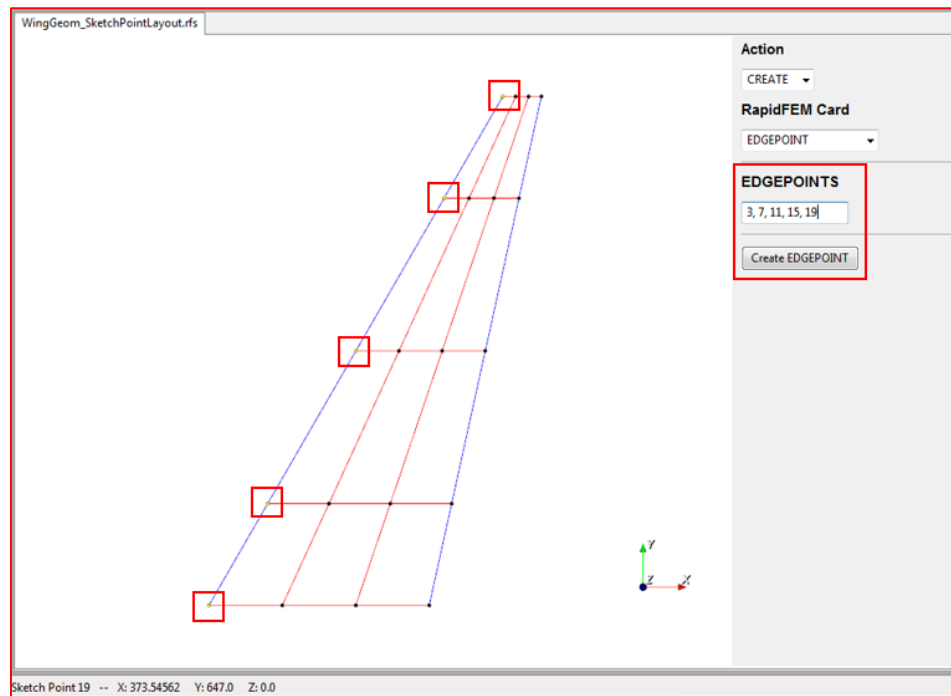| CARD	PROP TYPE	RID	MID	NSM	T	LALLOW	UALLOW	BMIR
prop	PSHELL	100	1	0.0	0.5	0.1	6.0	0.0

- Action: Create
- RapidFEM Card: BEAM
- Represent:
  - Ribs and Spars (Wing)
  - Bulkhead and Floor (Fuselage)
- BEAM Paver automatically creates BEAMs between two specified Sketch Points
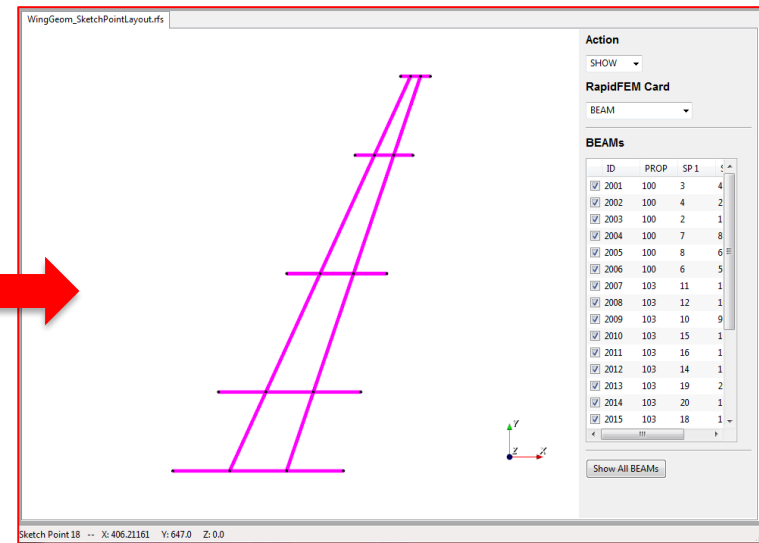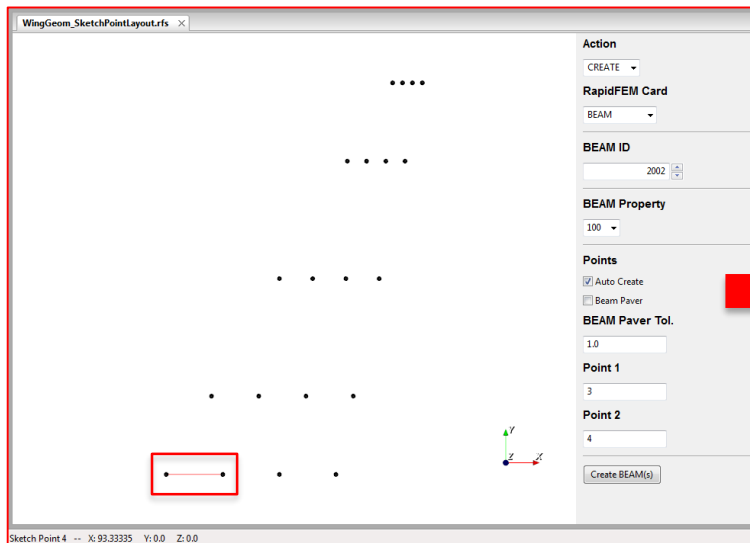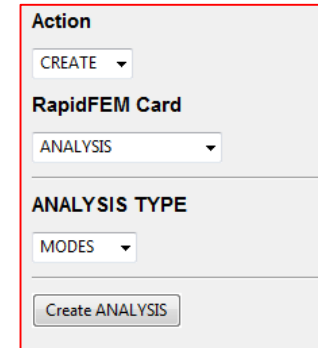
- ## Action: Create

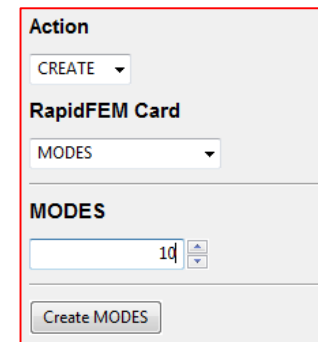- ## RapidFEM Card: SKIN4
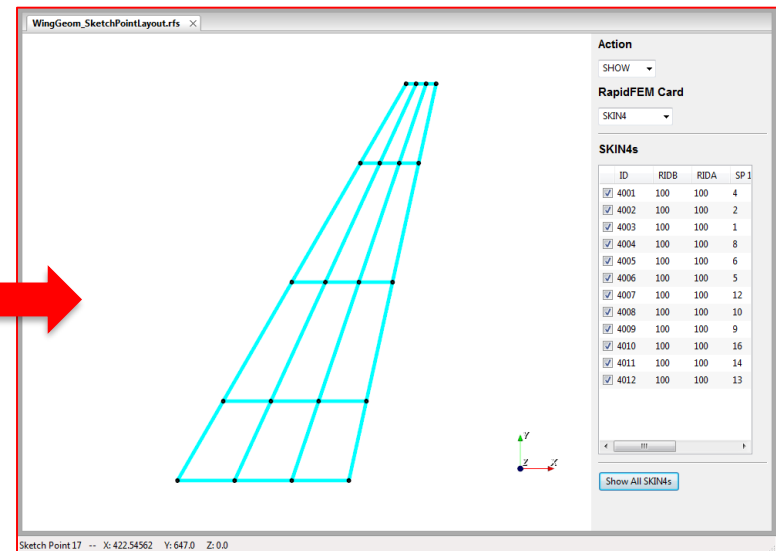
- ## Action: Create

- ## RapidFEM Card: EDGEPOINT

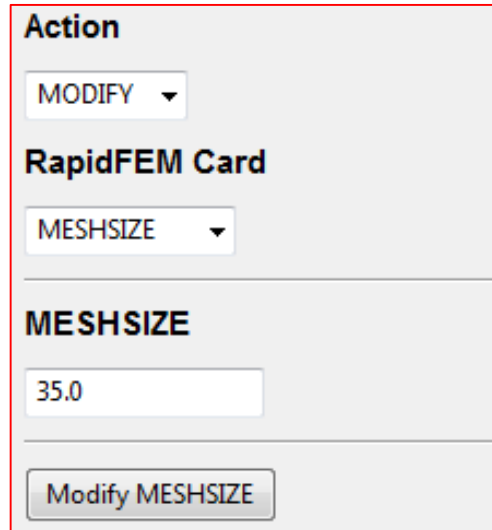- Action: Create
- RapidFEM Card: ANALYSIS
- Analysis Type: MODES

- Action: Create
- RapidFEM Card: MODES
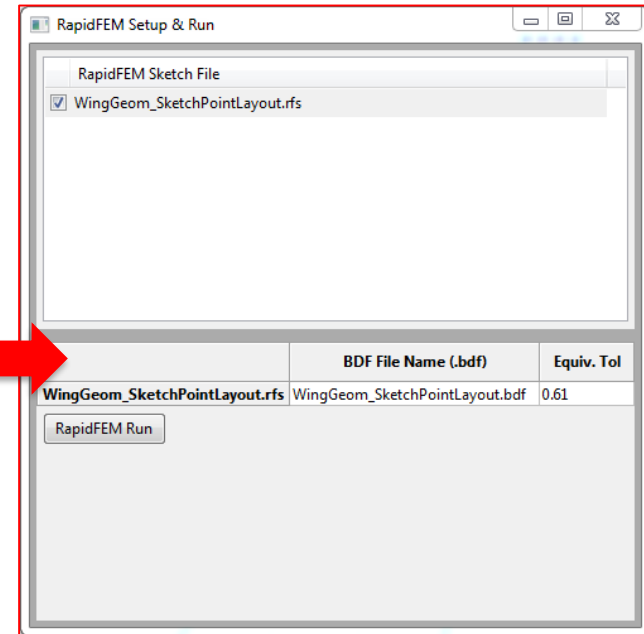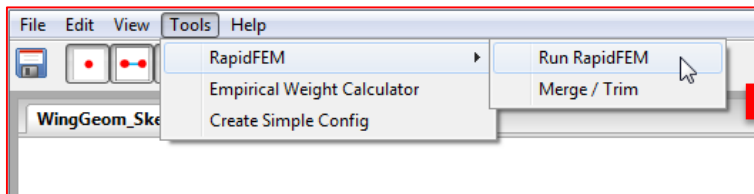- Number of Modes: 10

- Action: Modify

- RapidFEM Card: MESHSIZE

- Meshsize: 35.0

- ## Equivalence Tolerance: 0.61

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- Build 2
  - Enhanced Meshing
  - Enhanced Merging/Trimming
  - Automated Wing Layout Tool
  - Automated Fuselage Layout Tool
- Improved robustness and more unit testing
- More Example Problems

Thank You!

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